ELECTRON-ION COLLIDER DETECTOR ADVISORY COMMITTEE

Report of the 9th Meeting held on Thursday and Friday, 9 – 10 July, 2015

BNL, in association with Jefferson Laboratory and the DOE Office of Nuclear Physics, has established a generic detector R&D program to address the scientific requirements for measurements at a future Electron Ion Collider (EIC). The primary goals of this program are to develop detector concepts and technologies that are suited to experiments in an EIC environment, and to help ensure that the techniques and resources for implementing these technologies are well established within the EIC user community.

The EIC Detector Advisory Committee met at BNL on July 9 – 10, 2015. The Committee members are: M. Demarteau (ANL/Chair), C. Haber (LBNL), P. Krizan (Hamburg), I. Shipsey (Purdue/Oxford), R. Van Berg (U. Pennsylvania), J. Va'vra (SLAC), G. Young (JLab). Peter Krizan was unable to attend the meeting due to personal reasons. Three new proposals, nine progress reports and one consortium report were reviewed. At the previous meetings the committee suggested that those R&D groups with similar research topics form research consortia to make the overall program more efficient. The committee is pleased to see that the four groups studying particle identification for the EIC, eRD10 (TOF), eRD11 (RICH), eRD4 (DIRC) and the LAPPD group, have joined forces to work together on issues of PID systems that will address the full range of physics goals of the EIC. The committee also notes the stronger collaboration between the eRD3 and eRD6 tracking groups.

Thomas Ullrich reported on the status of the long-range plan of NSAC. There has been a Resolution Meeting of the LRP working group in Kitty Hawk, NC, in May 2015. The NSAC subcommittee on Scientific Facilities ranks an EIC as absolutely central to its ability to contribute to world-leading science in the next decade. The final recommendations are currently still under review and will be released in October 2015. It is expected that the EIC will be given highest priority as new construction project after the construction of FRIB has been completed. He also noted that the current detector R&D program was very well received by the community and the Office of Science and that there are many outstanding R&D issues that remain to be addressed in order to achieve the physics performance metrics.

General Remarks

The proponents are to be congratulated on the generally good quality of the talks, the focus of the work reported, and in particular on the extensive efforts to obtain the many results reported. The reports demonstrated in most cases responsiveness to prior charges and comments as well as ongoing dialogue among proponents of similar technical solutions. The committee would like to thank the proponents in their efforts to make the review process more effective and for following the advice given in the previous report. Also the increase in the number of publications is welcomed. There is, however, significant room for improvement in getting results published and all proponents are strongly encouraged to publish their results preferably in peer reviewed journals, but at a minimum on the archives.

The committee very much appreciates the effort to form consortia when research topics overlap. In particular, the effort by the LAPPD, eRD4 (DIRC), eRD10 (TOF) and eRD11 (RICH) groups to form a consortium is much appreciated. The eRD3 and eRD6 groups have a stronger collaboration, but have not yet fully merged. A joint workshop was held at Temple University on tracking at an EIC. The groups are encouraged to continue exploring possibilities to merge and articulate a coherent tracking R&D program.

The committee welcomes the new proposal to explore silicon based tracking for the EIC and hopes the proponents will form a close collaboration with the existing tracking groups to study the tracking requirements for an EIC.

The Committee notes that the timescale for CD-0 approval of an EIC is several years out, and establishment of a formal reference design for the chosen accelerator complex would be expected to occur 1-2 years beyond that. The opportunity and time horizon exist now to attempt R&D projects, which carry a higher degree of risk, yet hold the promise to advance the state of the art significantly. Proponents are encouraged to explore more innovative ideas.

The committee would like to iterate that the intent of this R&D program is to provide seed funding for promising research proposals that after a couple of years can be sustained on independent external funding. Proponents are encouraged to explore opportunities for external funding once their research program has been established.

This review was again particularly challenging because the funding request exceeded the available funding by a factor of nearly two, worsened by the fact that part of the allocated money is not available due to prior hiring commitments. This set of requests comes at a particularly difficult time when the research and operations budget of RHIC experience significant funding cuts. Very cognizant of the serious funding constraints and the balance between support for staff and equipment, the committee took a purposeful approach with respect to the funding recommendation. In particular, the request in the amount of $100k for non-recurring engineering (NRE) support for the company TechEtch to continue the development of large GEM foils at TechEtch was discussed at length. The development of the production capability in the U.S. for large-area GEM foils has important merit and would be ideally suited for the SBIR program. TechEtch, however, does not meet the DOE criterion for a small company. With very few projects coming online in the near future with a potential interest in large-area GEM foils, the true market for this technology lies outside of the Office of Science. Given that CERN is committed to supporting the currently proposed set of experiments and the very tight budget constraints, support for the NRE is not recommended at this point. The approach taken to address the significant shortfall in funding was to subdivide the proposals. The proponents were then asked to prioritize the subprojects. The committee then ranked the individual proposals as high, medium and low priority and appropriately adjusted the recommended allocation of funding to fit within the budget. The overall funding priorities are given in Table 1 at the end of this report. Summaries of the presentations with corresponding recommendations are given in the next section.

EIC Proposal for Compton Polarimetry R&D

Alexandre Camsonne reporting

The Committee again notes that it considers a high-quality polarization measurement program essential for the EIC and repeats its support for a Compton polarimeter test bed. The authors presented a concept for a Compton polarimeter located in the low Q^2 chicane of the MEIC. The MEIC accelerator lattice has been worked out to accommodate the needed features for the polarimeter. A few workable options for the location of the polarimeter in the eRHIC lattice are under consideration and will need further development to determine if any modifications to that lattice are needed; this effort is underway.

The authors have calculated the expected rates for detected Compton-scattered electrons and photons as a function of electron beam energy for both the eRHIC and MEIC designs. The crossing rates for MEIC vary from 159 MHz to 476 MHz, likely precluding resolving from which bunch the scattered electrons and photons originate. The crossing rate for eRHIC is planned as 10.8 MHz, which would encourage development of detectors, which can time-resolve the specific bunch-crossing from which an event originates. The authors have calculated the time needed to make a measurement with 1% statistical accuracy as a function of machine operating point, obtaining values ranging from 2 to 155 seconds. The authors have also calculated the radiation damage rates as a function of machine operating point, and have determined that a dose of 3 MRad corresponds to 443 down to 6 days of continuous exposure, depending on setup. This would suggest that the polarization can be measured only from time to time, for example once an hour, to minimize radiation damage to detectors while producing a time-record of polarization behavior (e.g. decay) during a store. The authors have also studied the energy deposition in beam pipes and exit windows and presented concepts for these.

The Committee recognizes that the MEIC crossing rate likely precludes resolving individual crossings, but repeats the comment that the interaction with the machine structure and dependencies of emittance growth and instabilities on bunch charge need to be studied by the accelerator experts. Unlike the CEBAF single-pass fixed target operation, bunches in a collider will evolve with time. Since all electron bunches in the MEIC collide with all ion bunches, absent the ability to time-resolve crossings, only the time-average *can* be measured, making it compelling to develop the initial simulations noted by the authors to the point that external reviewers can be convinced.

The authors note that further studies of the background are needed and mention that more studies of the synchrotron background is needed for an MEIC, due to the location of the chicane after the IP. A location for the polarimeter has not yet been determined for the eRHIC lattice and choices upstream of the IP are under consideration, in part to reduce background rates. The authors also mention methods to improve laser power, including pulsed laser options, and the Committee takes note of the multi-kW lasers developed and in operation for the JLab Hall A and C Compton polarimeters.

The Committee recommends further contact with various groups that have built silicon strip and pixel devices, in particular concerning timing performance and integration of electronics with sensors to minimize noise and footprint, as well as concerning radiation-resistant electronics.

Contact with the TOTEM experiment and the CMS-TOTEM Precision Proton Spectrometer is recommended to learn about their approach to the experimental issues.

The committee encourages the simulation studies leading to a full design of the polarimeter and the pursuit of an initial test chamber that would allow studies with the Hall C diamond detector. Bench studies of cooled and local (ASIC) electronics coupled to diamond detectors are encouraged as well to understand noise and timing performance. It is suggested to engage the JLab ion-source group to determine if a test using a 10 MHz rep-rate laser at the existing polarized ion source could be done to study polarimeter operation at 10 MHz bunch rate. The group should evaluate the direction of future development at the next meeting of the Committee.

Recommendation: The group is encouraged to proceed with the simulations for the design of a Compton Polarimeter at the MEIC.

DPMJetHybrid 2.0: A Tool to Refine Detector Requirements for eA Collisions in the Nuclear Shadowing / Saturation Regime

M. Baker reporting

The EIC as the first electron-ion collider has the potential to allow comprehensive measurement and understanding of gluon saturation effects that are an important part of the EIC physics program (*Electron Ion Collider: "the Next QCD Frontier Understanding the glue that binds us all"*). In order to ensure that the detectors designed for the EIC fully address the physics program it is important to incorporate models that include all relevant physics in the Monte Carlo simulation. Nuclear shadowing / parton saturation effects are currently not included in the suite of eA DIS event generators available for EIC physics simulations. It is proposed to upgrade the eA event generator DPMJetHybrid to include these effects. This will significantly improve the particle production model in the forward region for eA collisions along the ion direction. It will clarify the detector requirements for measurements at either eRHIC or MEIC with forward detectors, including centrality tagging and correlations between forward particles and jets from hard scattering. It is timely to specify quantitatively these detector requirements, as they are an essential part of the EIC IR design. The proposed work can be completed in one year. A timetable spread over two years was also presented. The deliverable is the code release. The budget is for support of the proponent at 0.25FTE. The committee was impressed with this proposal and Baker's knowledge during the presentation. The committee believes the work described will be an important contribution to the EIC program as the design of the detector is refined.

Recommendation: The funding request for the first stage at the level of $32,000 for the development of a simplified model and code release is recommended. The committee encourages regular interaction between the developer and the expected user community.

EIC Proposal for Forward/Backward Tracking at EIC using MAPS Detectors

Ernst Sichtermann reporting

The committee is pleased to see that an area of study in the EIC detector development community emerges with a focus on silicon-based tracking. The proposed work plan is modest and appropriate for a new inquiry. The committee looks forward to rapid progress and an expanding effort in this area. The committee has no issues with the proposed plan but makes the following comments or recommendations.

1) At the time of the next EIC meeting a basic conceptual layout of a forward tracker is expected, as discussed during the meeting
2) Aluminum conductors are well motivated by the needs to reduce mass. Due to the risks and difficult past experience with this technology the proponents are urged to consider fallback solutions carefully. In the forward direction perhaps the additional space for service routing allows more flexibility to use also traditional copper based conductors? The committee also asks if the need for via connections between Aluminum layers can be avoided. A simpler structure with metal layers, which are only interconnected by wirebonds, could be a more conservative approach, which still provides the needed electrical characteristics and performance.
3) The area of MAPS type sensor/electronics is expanding considerably with the work in the HEP community in HV-CMOS and High Resistivity (HR)-CMOS. Following these developments carefully is strongly recommended and developing an understanding whether any of these would become options for the EIC as well. As work and interest in precision tracking for EIC develops furthering any combined efforts with HEP would be to everyone's benefit.
4) It is noted that the Compton Polarimeter also requires a small electron tracker in the forward direction. The readout speed requirements are higher there. Nonetheless, there may be ideas and approaches, which could be applicable to both the Polarimeter and the F/B tracking station. The committee hopes the two communities will establish contact. Similarly we hope a good contact and dialogue will be established with the eRD6 / eRD3 Tracking consortia.

Recommendation: The committee strongly encourages carrying out the simulation studies leading to a design of the forward and backward tracking detectors.

PID Consortium for the EIC

P. Nadel-Turonski reporting

eRD10: TOF Detectors

The committee commends the collaboration on excellent progress in the area of TOF. We note the demonstration of the multi-gap RPCs (mRPCs) with glass layers, exhibiting record timing resolution since the last meeting. This development looks very promising and offers a very cost effective solution to TOF in both the barrel and forward regions with good performance in a magnetic field. Even with such good performance there are clearly many parameters still to be optimized, in particular to get to the 10 ps target. Such parameters include – glass composition and thickness, number of layers, spacers, gas, gas purity, gas pressure, and the use of other materials. The concern here is that the committee is under the impression that a fundamental understanding of this device from first principles is not known, neither by the team, nor by the greater mRPC community. From some perspectives these devices ought not work at all at high rate! This raises also questions about the rate dependence of the mRPCs. The committee urges the team to make efforts, experimental and/or theoretical to explore these issues and deepen the understanding of these devices and how their performance may evolve.

The 3D printing approach, while novel, was met with some skepticism since the roles of the spacers, being of the same material as the plates, seems problematic. If this is to be pursued further, it is recommended to try to make a definitive evaluation sooner rather than later in order to optimize resources.

Another issue to consider is systematics in a real system implementation. Suppose one could reach a resolution of 10 ps? How would one deal with the start signal? At some point the knowledge of path length, position, alignment, angles etc. becomes the dominant systematic. When does one hit this limit? It is suggested to consider how one would implement TOF in the various regions of the EIC detector and what further requirements or capabilities would be needed to actually put such a high performance tool to use.

Recommendation: understanding the fundamental properties and limitations of mRPC based timing detectors should receive high priority.

RD4: DIRC Based PID for EIC

Very good progress has been reported in the area of PID and the group has responded well to the last questions from the committee. The committee makes the following observations:

1. The collaboration with Panda is showing very nice MC results and the committee is eager to see a comparison between MC and the CERN test beam results. The committee would like to see these results at the next review meeting.

2. The committee encourages the group to develop their own data and MC analysis for Panda prototype in CERN test beam.

3. The establishment of the collaboration with GLUEX is also very much encouraged to find limits of lens-based optics, especially aberration effects such as kaleidoscopic effects, which is a fragmentation of Cherenkov ring due to square bars.

4. The committee would like to see a detailed MC comparison between lens and mirror designs using the same conditions, i.e., including a realistic track resolution with multiple scattering in the bar itself and its support structure.

5. The committee is pleased to see a procurement of the lens optics in place, and the lab activities to evaluate the lens design. These bench test results should be published as soon as they are available.

6. The committee would like to encourage taking advantage of obtaining some optical elements from Panda, and do tests including a single bar, lens and expansion volume box. Initial tests could use a laser, and later be followed with a simple cosmic ray telescope. This could evolve into a more complex program providing the know-how to build a DIRC.

7. Jefferson lab helped to setup a 5T test facility, which is now operational. Hopefully it will test a good version of LAPPD MCP-PMT, preferably with pixel readout.

It should be noted that, although a SiPMT could be considered in principle for DIRC readout, SiPMTs for FDIRC were rejected by SuperB, because of high noise rate after an irradiation dose of 10^{10} neutrons/cm^2.

PID: RICH

This effort looks at a number of different versions of Ring Imaging Cherenkov counters to enable / enhance hadron identification in the forward regions of an EIC detector. The work plan includes simulation of physics performance, studies of possible detector configurations and variants, laboratory efforts to produce a visible light sensitive GEM detector and, finally produce a prototype modular Cherenkov detector.

The consortium is looking at several basic RICH designs, all relying on aerogel for pion/kaon separation and, in some cases, including a gas radiator as well to either extend the range to higher momenta or to be used as a threshold counter for lighter particles. The basic designs cover use of a thin Fresnel focusing lens, simple proximity focusing or mirror focusing – each offering somewhat different capabilities, advantages and disadvantages. The collaboration is also looking at a "modular" design based on the Fresnel lens concept where individual detectors on the 10 to 20 cm scale are tiled into a full end cap system in an EIC detector. For all these cases the collaboration is considering either GEM or LAPPD areal readout.

We also suggest that the group pays attention to RICH counter developments elsewhere, for example the forward RICH detector at Belle-II, in order to avoid some mistakes, learn what works and what does not, and focus on new things needed to be developed.

The proposed budget for FY16 includes $102k for the simulation effort, $69k for the GEM photocathode effort and $55k to construct a prototype of an aerogel/Fresnel modular detector using a commercial multi-anode PMT readout.

The committee agrees with the prioritization provided by the consortium and supports the suggestion to delay the fabrication of prototype modules.

Recommendation: In the funding allocation, it is recommended that the DIRC based particle identification be given preference over the RICH based detectors. A RICH-based PID detector for the EIC's forward region should be studied through simulations.

PID: LAPPD

This effort has characterized one early test device produced by Argonne. The basic performance parameters of the tube are in good agreement with the measurements done at Argonne. The group has also setup a magnet facility where the device can be tested in a strong magnetic field. These tubes are very attractive for many detectors at an EIC detector. The committee supports the direction for development of MCP-PMTs. It is suggested to use MgF_2 windows to ensure that the window transmission does not cut into a peak in QE of bi-alkali or multi-alkali photocathodes. This could happen if a somewhat lower quality fused silica window is used. It is also suggested that photocathode experts investigate the condition causing the QE peak at ~180nm, as many "standard" QE curves do not show it.

Recommendation: Together with the development of pixilated readout, the committee regards the development of UV sensitive LAPPDs a high priority topic.

RD 2011-6 Tracking and PID for an EIC Detector

T. Hemmick reporting

The RD6 Consortium is working on a variety of tracking solutions for an EIC detector. Much of the work is centered on GEM detectors with some work incorporating two GEM foils with a Micromegas layer. The results of the mini-drift GEM tests are quite encouraging. Using both a chevron and COMPASS style readouts, the consortium obtained position resolutions that are very respectable (50 to 100 micron range) at small angles and, after correcting for the test electronics timing uncertainty, well under 200 microns at 45 degrees for the COMPASS style design.

The design of a "Common GEM Foil" that can be used by the different groups at Florida, Temple and University of Virginia in different configurations to study various issues such as frame design and assembly techniques promises to be of significant value. Examination of grid structures that could limit ion feedback also show significant promise.

Test beam results from campaigns at FNAL and SLAC have yielded important feedback on the design of future chambers to achieve the desired particle separation. Other initiatives such as

ultra low radiation GEM foils and frame designs allowing easier opening and foil adjustment or replacement are novel and promising.

The breadth of the consortium's work in design, simulation, construction and measurement is impressive and gives a coherent and even somewhat convergent picture of possible tracking options for a future EIC detector.

Recommendation: The design, construction and detailed testing of increasingly realistic tracking detectors provides both important information for the design of an EIC detector and builds an invaluable skill set in the EIC community. The work should be supported to the extent that funds allow.

Status Report and Proposal for EIC Calorimeter Development

O. Tsai reporting

W/SciFi Calorimeter Development

The group reported on the development of a W/SciFi calorimeter, which is capable of reaching an energy resolution of 10%/sqrt(E), which was actually achieved in very early prototypes. This development is strongly encouraged as a potentially good choice for the calorimeter. The very recent prototype, however, shows small light yield. Although the explanation might be very simple at the end, we recommend that the light yield is studied in detail to know the efficiency contribution of each element in the optics. That means: (a) fiber, (b) its reflectivity coating, (c) fiber polish, (d) fiber coupling to diffuser and SiPMT. This will allow optimization of the design.

SiPM Radiation Damage

The authors have exposed several SiPMs with 25 micron pixels to neutron fluences from 10^9 to 10^{13} n/cm^2 at LENS at Indiana University and then measured the dark current as a function of bias current. The group also exposed a group of SiPMs with 15 micron pixels in the PHENIX IR, putting them in three different locations: 90 cm from the IP; at the same location but including a Gd-foil overwrap to remove thermal neutrons from the incident flux reaching the SiPMs; and at the base of the central magnet next to a SPACAL block to study the effect of any spallation neutrons. Fluences in these cases were smaller than for the LENS irradiations, being less than 10^9 n/cm^2. The SiPMs exhibit a similar increase in dark current as a function of fluence. Future plans include irradiating devices with 10 and 15 micron pixels and exploring use of other sources at LANL and BNL.

Since Gd does yield several MeV of photons for each thermal neutron capture, a check measurement exposing a few SiPMs to ^{60}Co or other sources of purely gamma radiation would be useful. The measurements made by the GlueX collaboration using gammas from ^{60}Co and neutrons from PuBe would be of interest to the authors, as would GlueX's decisions about lowered SiPM operating temperatures and their front-end circuits for bias compensation and stabilization. The Committee takes note of the authors' plans to characterize the SiPMs as a function of temperature and operating bias before and after irradiation to guide design of the required compensating circuits.

PbWO4

The authors have obtained first test crystals from Crytur and begun measurements of their properties, and have set up various labs and performed measurements of existing PbWO4 crystals from SIC (loaned from JLab) as well as from BTCP, loaned from the University of Giessen. The last set in particular have served as a reference set both to qualify the lab setups as well as to serve as a reference for the newly-made crystals from Crytur. Studies of transmittance and absorption versus wavelength, both longitudinally and transversely along the crystal length, have been made. The Committee takes note of the good progress qualifying a new source of PbWO4 crystals, which will be important for the future. It also takes note of the check measurements made at the CalTech facility, which was used to characterize the CMS crystals. The Committee will be interested to hear future reports on how such measurements are developed into both a screening tool for giving feedback to crystal manufacturers, as a tool for quantifying radiation damage and determining acceptable limits for the same and advising manufacturers if a given series of crystals is more or less susceptible to damage, and as an acceptance tool for selecting crystals for use in a calorimeter.

Studies of radiation damage and resulting degradation of transmittance versus wavelength were started using the Idaho Accelerator Facility. Some further effort will be needed to optimize dose rates and profiles, as well as environmental effects such as temperature, but it is encouraging to see the start of these studies and preparation of the portable measurement apparatus needed to support them at the site. It was observed that there can be spontaneous recovery (annealing?) of the dose damage on a time scale of 2.5 days, pointing out the need for timely measurements during such irradiation studies. The Committee notes that there are plans to make irradiation studies at BNL and CIT, and a collaboration-wide effort is forming to study how these observed effects would bear on the performance of a forward-angle crystal calorimeter at EIC.

Initial results were reported on coupling SiPMs to one crystal. The Committee will be interested to learn the results from these studies as they develop, and also suggests making contact with the GlueX group concerning their developments for temperature and bias voltage control and compensation for SiPMs. The authors plan to develop the infrastructure to test a crystal array, for example a 5x5 array, using the setup being built at JLab for the Neutral Photon Spectrometer. The Committee will be interested to learn of further work here, for example on the allowable dead space between crystals that allows preserving resolution.

Shashlyk EMCal

UVa has joined the eRD1 calorimeter consortium. The proposed new contribution under the leadership of Xiaochao Zheng focuses on simulations and prototyping of a Shashlyk EM sampling calorimeter that has the potential to provides good energy resolution and high radiation resistance, at a lower cost than a crystal calorimeter. It can, in addition, be made in a fully projective geometry. A novel aspect of the proposal is the investigation of the production of scintillator plates using 3D printing.

The following R&D steps are proposed: preliminary simulations to determine a basic design of Shashlyk calorimeters for the EIC's outer electron and hadron endcap calorimeters, and a study of the feasibility of using Shashlyk for the barrel calorimeter. Preparatory work towards

Shashlyk module construction that will focus on testing the optical and mechanical properties and the radiation hardness of the scintillator and absorber components of the module is proposed.

In addition to using scintillators produced with traditional methods, the proponents will, in due course, incorporate 3D-printed scintillators. 3D-printing allows production of projective-shape modules.

Once the design is determined and the basic data on properties of the scintillator and the absorber components have been obtained the proponents propose to proceed to prototype construction, focusing on the endcap calorimeters and the possibility of producing projective-shape modules. The funding request is for one year only. It is dominated by manpower: funds for 0.25 of a postdoc, and 0.5 of a graduate student.

Recommendation: A complete and detailed study of the loss of light yield of the W/Scifi calorimeter is recommended before another module is constructed. This calorimeter seems to meet the specifications for an EIC and support for continued R&D is recommended. The Committee supports further development of the PbWO effort, if funding permits, with a focus on characterizing new crystals and potential radiation damage as well as qualifying suppliers. The proposal for construction of a shashlyk calorimeter is well received and further development of the concept is strongly encouraged.

Status Report on A Compact Magnetic Field Cloaking Device

R. Cervantes reporting

The authors have continued prototyping the magnetic cloaking device and demonstrated that they could shield a field up to 55 mT. They developed models to predict performance of larger multi-layer shields. They determined the limits to shielding improvement possible with the narrow high-Tc tape used previously. In collaboration with the supplier of the high-Tc tape they have obtained much wider samples, 46mm wide, which permit wrapping a relevant-size tube longitudinally, avoiding the previous spiral wrap. They demonstrated that this method provides both better shielding power as well as scaling to a larger number of layers in a much more encouraging manner. This result promises the possibility of a 40-layer shield with this wider tape that could shield 0.5T at LN_2 temperatures, a goal of the study. The authors also note that this tape operating at LHe temperature would shield 0.5T using only 11 layers.

The authors demonstrated a technique for constructing the needed outer ferromagnetic shield with a controlled permeability by casting a mix of stainless steel powder (permeability 500) and epoxy (permeability 1) to obtain a mix with permeability in the needed range of 1 to 6. The resulting material can be cut and reassembled and maintain the needed properties.

The work with the Superconducting Magnet Division (SMD) and the Collider Accelerator Department (CAD) to define potential cryostats for LN_2 and LHe operation still needs to progress to be sure that such a device can be integrated with the EIC lattices, and the physics

justification case needs to be prepared for inclusion in any future proposal for an EIC detector wanting to use a forward dipole spectrometer.

The Committee continues to be interested in the work but emphasizes the need to progress to demonstrating the concept works for 0.5T fields.

Recommendation: It is recommended that Brookhaven management find a way to accommodate the high field tests in the magnet division. Significant progress has been made and continuing R&D with an emphasis on demonstrating the concept at 0.5T is highly encouraged.

Progress report and Proposal for the Design and assembly of fast and lightweight barrel and forward tracking prototype systems for an EIC

B. Surrow reporting

The committee continues to be impressed by the progress made on both Micro-Megas and GEM detectors for possible barrel and forward tracking systems at an EIC. Temple University has been able to build up an impressive infrastructure for the testing and fabrication of MPGDs. The detailed optical characterization of single mask GEM foils is clearly of great benefit to improving quality control by the manufacturer. The development of a close relationship with a commercial vendor has been excellent to date. The request for NRE funding, however, is difficult to fulfill in this tight budget climate. Tech-Etch is encouraged to initiate a dialogue with the DOE/SBIR office to explore possibilities on meeting the requirements for an SBIR grant. The group needs an upgrade of the CCD scanner to accommodate scanning of large GEM foils. The design of a large, dedicated EIC triple-GEM segment of ~50x100 cm^2, in collaboration with Florida Institute of Technology and University of Virginia, has been finalized. Bi-weekly coordination meetings are taking place between the collaborating institutions, CERN and Tech-Etch on technology transfer.

The barrel MicroMegas work at Saclay is very impressive and good progress has been made in a number of challenging areas. Much of the work has been supported by internal Saclay funds to continue the MicroMegas R&D program. Design and assembly of a barrel MicroMegas at large radius with z and phi resistive readout was completed and the DAQ system based on the DREAM chip was exercised. Several prototypes were produced and subjected to cosmic ray tests. An overall hit efficiency of >98.1%, with a spatial resolution better than 200μm and time resolution around 25ns was achieved. The budget request includes effort support, materials and services and a request for NRE support for Tech-Etch. The work to date and plan forward on readout is sensible as is the simulation work.

Recommendation: Progress on both the GEM and MicroMegas chambers is very good. Continuing support is recommended as permitted by funding constraints.

eRD12 Progress Report - Status Update on Polarimeter, Luminosity Monitor and Low Q2-Tagger for Electron Beam

R. Petti reporting

The low Q^2-tagger as currently envisaged consists of three (originally 2) tracking layers (to measure the electron scattering angle) and an EM calorimeter for the measurement of the electron energy at 15 meters from the IP, 2cm transverse to the beam. The device is simulated in Eicroot, which has now been made more realistic. There is a concern that the electron energy will be difficult to accurately measure as its trajectory is close to the edge of the calorimeter. The results of simulations show reasonable energy reconstruction and good coverage down to low Q^2.

The ep -> γep Bremsstrahlung process will be used to measure the luminosity to a target precision of 1%. The system needs to be fast enough to give feedback to the machine on luminosity steering. Based on the design from ZEUS at HERA-II, a luminosity monitoring system is included in the IR simulation. The simulation is being used to determine the best location for the luminosity measurement. The luminosity system consists of a photon transport line with a converter end cap, a dipole magnet for a pair spectrometer, and a triplet of electromagnetic calorimeters. A central calorimeter on the beam axis captures Bremsstrahlung photons that have not converted in the end cap and calorimeters placed directly above and below the central calorimeter in the vertical direction capture the electron-positron pair from the photons that convert in the end cap. The simulations show that the beam conditions dominate the expected cone size of Bremsstrahlung photons and that the luminosity monitor has sufficient acceptance within the current IR design

The layout of the Roman Pots including the number of stations and locations of beam line magnets to give more room to a Roman Pot station is being studied. Preliminary results shown in the presentation, but not in the report, show good overall coverage in t in the current IR design, but there is some loss at high t. There is a need to consider a station very close to the main detector

For the electron polarimetry, discussions have been initiated to identify a suitable place for the polarimeter. It is considered likely that the polarimeter system will not be integrated into the IR, but will be installed elsewhere, possibly in another IP hall. The main effort for the coming half-year will be the electron polarimetery design. It is important to integrate the polarimeter into the machine lattice from the beginning to minimize backgrounds.

In addition to all of the above the *Eicsmear* software package development has continued.

Recommendation: The committee was pleased to see the progress that has been made in the last six months and looks forward to hearing more about the work in particular the electron polarimetry at its next meeting.

Overall Funding Recommendation

Given the limited amount of funding available, the committee was charged to provide a prioritized list of projects to be funded. The proponents were asked to subdivide their research program and prioritize the individual components. The committee took the ranking of the proponents into consideration and provided a ranking of high, medium and low priority, which is provided in Table 1. It should be noted that the ranking of the committee is based on a balance between the success of the ongoing elements of a research proposal and the limited funding available. It is no judgment on the merit of the research.

As noted earlier, given the very difficult budget climate, the request for NRE support for the development of large GEM foils at Tech-Etch, given that these foils can be provided by CERN for R&D purposes, could not be supported. This view was conveyed during the close-out meeting with the proponents. After the meeting, a new proposal was submitted by the eRD3 and eRD6 groups. A request was made for post-doc support at FIT for $92k, support for GEM research at FIT and UVA at the level of $14k per institution, and a request to optimize and complete the development of 50 cm large GEM foils at Temple University. This request was considered by the committee after the meeting and is supported. The MicroMegas work was given low priority without prejudice. The ranking is purely based on the current success in the area of GEM detector development and the limited availability of funding. It is not a judgment on the necessity or capability of the group to engage in the development of a central MicroMegas tracking system for an EIC detector.

The eRD1 consortium placed the shashlyk work at lowest priority. While they welcome and support this effort they give priority to ongoing projects with existing commitments. The consortium noted that with partial support the shashlyk work could continue. The committee holds that preparatory work towards the development of a shashlyk calorimeter is a valuable contribution to the EIC instrumentation program. Given the very constrained funding situation, however, no funding could be awarded at this time but the proponents are very much encouraged to further develop the concept.

The proposal from the PID consortium consists essentially of four subprojects. The psec timing proposal and the DIRC based PID for the barrel detector, are highly recommended. The testing of the small form-factor LAPPDs is also strongly encouraged, given that prototype detectors are now more readily available. For the forward RICH particle identification project, the simulation studies are fully endorsed by the committee to understand the potential performance of various detector options. The Committee did not see a way of funding the GEM photocathode work given the available funding.

It was noted that the funding request for the magnetic cloaking device was a factor of three higher than previous requests. As stated before, Brookhaven management is strongly encouraged to find a solution to carry out the magnetic field tests in the magnet division that does not impact the detector development budget. The request for materials is fully supported by the committee. Support for students and postdocs can only be given as allowed by the available funding.

EIC Detector R&D FY2016	**PI**	**Proposal Name**	**Sub-proposals**	**Priority**
	Alexandre Camsonne	A proposal for Compton Electron Detector R&D		
			Simulation leading to design of polarimeter	**High**
			Chamber construction / electronics	**Medium**
	Mark Baker	DPMJetHybrid 2.0: A Tool to Refine Detector Requirements for eA Collisions in the Nuclear Shadowing / Saturation Regime		
			Simplified model and testing	**High**
			Full model and testing	**Medium**
	Barbara Jacak	Forward/Backward Tracking at EIC using MAPS Detectors		
			Simulations (+travel)	**High**
			MAPS R&D and cables	**Low**
eRD1	Huan Huang Craig Woody	Status Report and Proposal For EIC Calorimeter Development		
			W/ScinFiber Calorimeter	**High**
			SiPM Test and Simulation	**Medium**
			PWO Development	**Medium/Low**
			Shashlyk Calorimeter	**Medium**
eRD2	Abhay Deshpande	A Compact Magnetic Field Cloaking Device		
			BNL Magnet Division	**Outside funding**
			Cloaking R&D Program	**High**
eRD3	Bernd Surrow	Design and assembly of fast and lightweight barrel and forward tracking prototype systems for an EIC		
			NRE TechEtch	**Low**
			Postdoc + travel	**High**
			Materials: foils + CCD scanner	**Medium**
			MM Readout	**Low**
eRD6	Klaus Dehmelt	RD6 Tracking/PID Consortium: Progress Report & Funding Request		
			Postdoc at FIT	**High**
			CERN GEM Support at FIT	**High**
			CERN GEM Support at UVA	**High**
			Joint effort GEMs (NRE)	**Low**
			Continuing TPC efforts (BNL)	**Medium**
			Continuing RICH efforts (Stony Brook)	**Low**
eRD12	Elke Aschenauer	Polarimeter, Luminosity Monitor and Low Q2-Tagger for Electron Beam		**High**
PID Consortium	P.NadelTuronski, M.Chiu, H.van Hecke, Carl Zorn	Proposal for an integrated program of Particle Identification (PID) challenges and opportunities for a future Electron Ion Collider (EIC)		
		eRD10 (Mickey Chiu, Matthias Grosse-Perdekamp)	(Sub) 10 Picosecond TOF Timing Detectors at the EIC	**High**
		eRD11 (Hubert van Hecke, Carl Zorn)	RICH detector for the EIC'S forward region particle identification - Simulations	**Medium**
		eRD4 (Pavel Nadel-Turonski)	DIRCbased PID for the EIC Central Detector	**High**
		eRD11 (Carl Zorn)	Characterization of LAPPD 6x6 cm2	**Medium**

Table 1: Summary of the funding recommendations.